Referring now to FIG. **2**, there is shown a system similar to that disclosed in FIG. **1** hereinabove, modified in accordance with a further embodiment of the present invention. A third comparator **66** replaces the initial cushion timer **53** shown in FIG. **1**, and serves to actuate relay contact **62** and **63** through energization of winding **72**.

One input terminal of comparator **66**, hereinafter referred to as an initial cushion comparator, receives a ram position signal from potentiometer **58**. The other input of the initial cushion comparator receives a reference signal from summing junction **75**. The signal arising at junction **75** is derived from an adjustable reference potentiometer **69**, and from an accrued sampled error signal supplied by integrate-and-hold circuit **56**.

In operation, initial cushion comparator **66** is energized when the position signal received from potentiometer **58** obtains a predetermined relationship with the reference signal, including the sampled error signal, derived from summing-junction **75**. Thus, when the ram attains a position determined by the adjustment of potentiometer **69**, and a sampled error signal, coil **72** is energized to cause normally-closed contact **62** to open, and contact **63** to close. This effectively lowers the hydraulic pressure in chamber **34** by diminishing the flow of hydraulic fluid available from pump **36** by modifying the setting of valve **38**, and by opening relief valve **40**. The net effect is to lower the previous injection pressure applied through piston **32** to ram **10** to a suitable holding pressure.

By suitable adjustment of potentiometer **69** the point at which the initial cushion comparator **66** is activated may be controlled as a function of the final cushion position of ram **10**. The point at which the change from injection to holding pressure occurs may therefore be related to the terminal ram position (final cushion point). The relationship of the initial cushion point to the final cushion point is maintained through the feedback error signals supplied by the integrate-and-hold circuit **56**. As set forth above, the error signal also modifies the position at which screwback and pullback occur, thus maintaining the constant shot volume in the presence of correction in ram position.

It will now be appreciated that the control system described herein monitors final ram position after the expiration of a fixed period of time, regardless of transient pressure or velocity chatacteristics and institutes holding pressure as a function of ram position. While it is recognized that, generally speaking, a marked decrease in velocity and an increase in pressure occur when ram **10** achieves filling of the mold, it has been found that a reduction in ram pressure at this point may be instituted as a function of ram position. This avoids the necessity for monitoring a suddenly-changing variable such as pressure or velocity. Were pressure utilized as a control parameter, a temporary blockage in nozzle **14**, creating a transient pressure rise, might trigger the pressure responsive mechanism and falsely indicate complete packing of the mold. Conversely, were velocity of the ram to be taken as the measure of mold filling a temporary sticking or deceleration of the ram due to irregularities in the hydraulic system, improper operation of the hydraulic valve, or excessive friction within barrel **12** would generate a signal erroneously indicating complete filling of the mold.

By allowing sufficient time to pass for a nozzle blockage to clear and temporary sticking of the ram to be overcome the present system assures that the position error signal sampled by integrate-and-hold circuit **56** will represent the true termination point of the ram stroke. Therefore, the signal applied by circuit **56** to comparators **66, 67** and **68** will reflect only actual errors in ram position and not mere transient phenomena. However, it must be recognized that occasional irregularities in machine operation may still result.

For this reason, should a failure occur such that the ram has not advanced past some predetermined minimum position when timer **52** times out, the accrual of an unusually large error signal by comparison circuit **55** or integrate-and-hold circuit **56** will disable the circuit and energize alarm **60**. This activity will prevent the creation of an inordinately larger error signal by the various comparators and alert an operator to the failure of the machine. Similarly, to avoid the bottoming of ram **10** within barrel **12** due to the undue advancement, of the ram, should the position signal produced by potentiometer **58** reflect undue advancement a minimum error signal will be produced by circuit **56** for effecting a correcting retraction of the ram.

It has been found feasible in practicing the invention to adjust the control system elements so that an error signal is produced which is only about one-fourth that theoretically required to return the ram cushion position to its desired location. In this manner, frequent drastic correction of ram position is obviated and the chances of ram position oscillating about a desired point are minimized. Rather, the ram will be caused to gradually achieve a desired position by adjusting it in ever-smaller increments.

As will be evident from the foregoing description, certain aspects of the invention are not limited to the particular details of the examples illustrated, and it is therefore contemplated that other modifications or applications will occur to those skilled in the art. It is accordingly intended that the appended claims shall cover all such modifications and applications as do not depart from the true spirit and scope of the invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A control system for an injection molding machine including a ram and having drive means for rotating, and hydraulic means for advancing and withdrawing said ram, said control system comprising:

position sensing means for producing a position signal indicative of ram position;

reference means for producing a first position reference signal;

circuit means connected to receive said position signal and said reference signal for producing an error signal representing the difference therebetween;

first control means for causing pressure applied by said hydraulic means upon said ram to decline from a first, higher value to a second, lower value;

second control means responsive to said error signal for establishing a point for termination of operation of said drive means; and

third control means responsive to said error signal for establishing a point of maximum withdrawal of said ram.

2. The invention defined in claim **1**, wherein said first control means comprises a timer for effecting a decline in said applied pressure a predetermined time after initiation of ram advancement.